MODULAR WIND TURBINE TRANSMISSION

This invention relates to a wind turbine gear unit and in particular, but not exclusively, to an integrated rotor bearing wind turbine gear unit for multiple generators.

Torque transmission gear units for large multi-megawatt wind turbines currently face a range of design challenges. They have to be able to transmit the rotor power reliably, yet weigh as little as possible, cost as little as possible and be designed in such a way as to allow easy repair when required. Serviceability of the gearbox in the nacelle is very important in these large units because it is very costly to remove them, especially from offshore sites, to be repaired elsewhere. When serviceable in the nacelle, the design must be such as to reduce downtime to a minimum.

Another important design consideration is integration, implying that the gear unit must aim to take over as many structural tasks from the traditional wind turbine housing as possible. This means lower costs and lower overall weight. Furthermore the gear unit must be designed as compactly as possible, as this would again be beneficial for cost and weight.

In accordance with one aspect the present invention provides a wind turbine gear unit comprising a low speed gear module and a plurality of high speed gear modules wherein said low speed gear module is operable simultaneously to transmit torque to each of said high speed gear modules.

At least one of said high speed gear modules may be a multi-stage gear unit and said low speed gear module may be a multi-stage gear unit.

The gear unit(s) described below address the above issues and other issues by virtue of utilising:

i) Integrated rotor bearings.

ii) Modular design, mechanically and electrically.

iii) Multiple (small) generators.

iv) Gearbox housing used to transmit rotor loads to tower.

v) Absence of troublesome HSS (high speed shaft) couplings with generator(s)

Further aspects of the present invention will become apparent from the following description, given by way of example only, of embodiments of the invention in conjunction with the accompanying drawings in which: -

Figure 1 shows a schematic diagram of a wind turbine gear unit according to the present invention; and

Figures 2 and 3 show in more detail variants of the invention.

In Figure 1 a wind turbine rotor assembly (1) is coupled to the low speed gear element (2) of the gearbox, which may be either a bull gear or a ring wheel. The rotor is supported on an integrated bearing / bearings (4) which also locate the low speed gear in the gear housing (5). When using a ring wheel as the low speed gear element the bearing(s) (4) can for instance be situated on the outer diameter of the ring wheel.

The low speed gear drives several individual single or multiple stage low speed gear units (7) that may be comprised of planetary units, helical units or a combination of both. The secondary gear drive units (7) in turn drive several individual or multiple stage gear high speed gear units (8) that may be integrated or coupled to the generators (9).

The concept of the present invention may be characterised by: -

- Power split to multiple generators. Rotor power is split in the first low speed stage resulting in completely independent mechanical torque transmission paths to the different generators.
- Modularity - Several modules can be identified:

A) The gearbox housing which doubles as a structural element that transfers the rotor forces and bending moments to the nacelle frame structure.

B) Low speed module consisting of either a ring wheel or bull wheel supported on a bearing or bearings, coupled to several pinions that may drive single or multiple low speed stages.

C) High speed module consisting of one or more helical or planetary stages (or a combination of both) and a generator. The high-speed modules could be identical to one another but do not have to be. Furthermore the generator can be integrated with the final high-speed stage or flanged onto the high-speed stage housing.

- A control system allowing operation of the wind turbine without one or more generators.

- Operation of the wind turbine may be continued with one or more of the high-speed modules removed.

- Disassembly in the nacelle: All modules are removable but the main gearbox housing can be left in place to fulfil its structural role even when the turbine is not operational. The housing can be integrated with the base plate of the nacelle (6).

Figures 2 and 3 show in more detail examples of possible practical executions of the system described above. (Note: Underlined item numbers refer to equivalent areas or items in Figure 1)

In the construction shown in Figure 2 the wind turbine rotor is attached to the low speed shaft (1), which turns the low speed wheel (2) and drives several pinion shafts (3). The low speed shaft is supported on two main bearings, (4) and (5), which also act as the rotor bearings.

The pinion shafts are supported by two bearings (6,7) which are housed in the main housing (8) and the planetary unit mounting plate, (9). A wheel (10) can be mounted on each pinion shaft which then meshes with a second pinion (11). The pinion is connected to the planet carrier (12) via a spline connection that may be either a loose or shrink fit. The pinion is supported on its other end by a bearing (13) housed in the main housing.

The geared generator module, (14), comprises a planetary gear unit and a flanged on or integrated generator (15). The module can be attached to the planetary unit mounting plate via a flange (16). The planetary unit comprises a rotating planet carrier, a stationary ring wheel (17) and rotating planets (18). The

sun shaft from the planetary stage, (19), drives the generator via a spline coupling and is supported by the mesh on the one side and by the front generator bearing on the other.

In the construction shown in Figure 3, the rotor is attached directly to a ring wheel (20) that is supported by one large main bearing (21). Alternatively two main bearings may be used. The bearing is axially constrained on the ring wheel by means of a split ring (22), and on it's outer diameter by part of the central bearing support plate, (23). The ring wheel drives several pinions (24) that are supported by two bearings, the first (25) which is housed in the front bearing support plate (26) and the second (27) in the planetary unit mounting plate (28). (Note this is a variant of item (9) in Figure 2)

The front support bearing for the pinion (30) driven by wheel (29) is housed in the central bearing support that in turn is bolted to the main housing (31). The geared generator module can be identical in both of the constructions of Figures 2 and 3.

In both constructions, the main housing is fixed to the interface with the rest of the wind turbine' s structure via supports (32) that form part of the main gearbox housing. The supports could be extended into a multifunctional "L" shaped base plate (33) that would support the gear unit and rotor as well as the yaw bearing (34) of the wind turbine nacelle.

Modularity is a significant aspect of the invention. By virtue of modularity the turbine rotor power is split at the first stage and forms independent paths to the generators. This implies that the turbine could operate with as many of these paths as is desired. This would also be beneficial in low wind situations or if one or more of the generator modules is removed for maintenance. Furthermore, the modules could be used in different wind turbine sizes. This has logistical advantages for the wind turbine manufacturer's service department.

A major advantage of splitting the rotor power into independent paths is that there are no load sharing problems between the individual pinions. The loads are balanced by equalising the power delivered by the different generators.

Integration is another important feature. Once assembled, the main housing could become part of the turbine structure and does not need to be removed again. The unit is designed in such a way as to allow the disassembly of all the gearbox internals. Furthermore, the wind turbine rotor bearings are integrated in the unit in both illustrated constructional versions, enabling compact overall design, lower weight and cost saving.

In conventional designs a flexible coupling has the burden of taking up misalignment between the generator shaft and gearbox HSS. In this design the sun shaft is directly coupled to the generator using a spline connection.

(high speed shaft